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Labor & Wages

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An Aggregate Model of Supply and Demand for Labor in the Coosa Valley Area of Georgia

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An aggregate model of supply and demand for labor is presented for a sub-area of Georgia. Results show that agriculture of the area is no longer a significant source of labor for industry even though labor returns in agriculture are not competitive with labor returns in other industry.

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AN AGGREGATE MODEL OF SUPPLY AND DEMAND FOR LABOR IN THE COOSA VALLEY AREA OF GEORGIA

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Introduction

The purpose of this paper is to present a systematic construction of a regional model for assessing impacts of resource constraints on an area economy. Particular emphasis is placed on labor supply. Agriculture has, historically, furnished the labor pool for economic growth and development. Some critics have even argued that the growth of technology in agriculture has in fact displaced labor from the farm faster than it could be absorbed by industry. To what extent is this true under current economic conditions? What are the relationships among agricultural output, labor supply, profitability in agriculture, non-farm wages, and growth of the non-farm economy? These are questions of aggregate impact and can only be answered by aggregate economic analysis.

Impact analysis using input-output (I-O) models is already a popular and effective means of quantifying direct and indirect effects of exogenous forces upon a particular economy (Schnittker). One of the basic assumptions of an I-O based impact analysis is an inexhaustable or a perfectly elastic supply of the resources needed to produce the output required by exogenous demand forces. Current shortages of resources indicate that this assumption is usually false. The procedure used to introduce resource constraints on the input-output model is to include the input-output matrix in a linear programming framework. Examples of this kind of model are found in Gass and in Schluter and Weeks. Our

research follows this general concept, but departs from it mainly as we construct a factor market approach. The contrast is explained as follows.

General Structure of the Model

The familiar total impact analysis coefficients available from an I-O model are linear combinations of the total requirements or $(I-A)^{-1}$ matrix. Thus, it is first necessary to build a regional I-O model. One of the location quotient methods (Mustafa) was adapted in this study to estimate the technical coefficients of a 28 sector economy where the first sector represents agricultural activity. Then, the agricultural industry was disaggregated by Liu into 16 economically important producing activities (sectors of the region) (Liu). The output activities of the agricultural and non-agricultural sectors are listed in Tables 1 and 2.

The general input-output formulation for output requirements for a given level of final demand is:

$(I - A)X = Y$, or;

$X = (I - A)^{-1} Y$

where: X = an n x 1 vector of gross sector outputs

I = an n x n identity matrix

A = an n x n matrix of direct input requirement coefficients

Y = an n x 1 vector of final sector demand

$(I-A)^{-1}$ = an n x n total requirements matrix

$(I-A)$ = Interindustry requirements matrix.

Any linear programming model can incorporate the I-O model by use of two principal matrices; they are the interindustry requirements matrix as mentioned above and the resource constraint matrix. Furthermore, the

interindustry requirements matrix may contain the disaggregated agricultural production submodel and a non-agricultural production sub-model. The resource constraint matrix may contain labor, land and other restraints applying to both sub-models.

A simple and general linear programming model that would maximize total output of sectors in Tables 1 and 2 is described as follows:

Maximize X

Subject to $(I-A)X \geq Y$

$CX + IT = W$

$X \geq 0$

where:

X = a 43 x 1 Vector of economic sector activities

Y = a 43 x 1 Vector of final demands for the economic sectors

(I-A) = a 43 x 43 matrix of activities listed in Tables 1 and 2

C = a m x 43 matrix of resource or primary factor requirements for producing sectors

I = Identity Matrix

T = a m x 1 Vector of slack activities

W = a m x 1 Vector of resource or primary factor stocks available

m = Number of resource restraints.

Specification of a Short Run Area Model To Maximize Farm Income and Non-Farm Wages in the Coosa Valley Area

Objective Function and Structure

The objective function of the model used in this study differs from the general approach and may be defined as the short-run optimization of farmers' aggregate net cash returns and non-farm workers' aggregate labor

income. The structure of the restrictions and objective function are specified completely as follows.

Objective Function:

$$\max. \sum_{i=1}^{16} (-Z_a^i X_a^i + Z_b^i X_b^i - Z_c^i X_c^i - Z_d^i X_d^i) + \sum_{j=1}^{27} (Z_e^j X_e^j + 0X_f^j) - M \cdot IML$$

Subject to:

$$\underset{43\times16}{(I-A)} \underset{16\times1}{X_a} + \underset{43\times27}{(I-A)} \underset{27\times1}{X_f} \geq \underset{43\times1}{Y}$$

$$\underset{16\times1}{-X_a} + \underset{16\times16}{Z_b} \underset{16\times1}{X_b} = \underset{16\times1}{0}$$

$$\underset{16\times16}{FL_s} \underset{16\times1}{X_b} - \underset{16\times1}{X_c} = \underset{16\times1}{0}$$

$$\underset{16\times16}{FL_u} \underset{16\times1}{X_b} \underset{16\times1}{-X_d} = \underset{16\times1}{0}$$

$$\underset{27\times1}{-X_e} + \underset{27\times27}{NL} \underset{27\times1}{X_f} = \underset{27\times1}{0}$$

$$\underset{1\times16}{1} \underset{16\times1}{X_c} + \underset{1\times27}{1} \underset{27\times1}{X_e} \quad -IML \leq \underset{1\times1}{WL_s}$$

$$\underset{1\times16}{1} \underset{16\times1}{X_d} \leq \underset{1\times1}{WL_u}$$

$$\underset{1\times16}{1} \underset{16\times1}{X_c} \leq \underset{1\times1}{FOP}$$

$$IML \leq \underset{1\times1}{SIM}$$

$$\underset{1\times16}{LD_b} \underset{16\times1}{X_b} \leq \underset{1\times1}{WLD}$$

$$\underset{1\times16}{K_a} \underset{16\times1}{X_a} \quad \underset{1\times27}{K_f} \underset{27\times1}{X_f} \geq \underset{1\times1}{0}$$

Where: Z_a^i = Total farm variable cost for 1 dollars worth of farm output activity i. Subscript a denotes activities of the model where farm costs are calculated.

X_a^i = Total dollar cost of farm output i.

Z_b^i = Farm price received for 1 unit of output i (Table 1). Subscript b denotes farm output activities.

X_b^i = Total physical quantity of farm output i; Note that $Z_b^i X_b^i = X_a^i$

X_c^i = Total skilled labor hours used for farm output i which has an objective function value Z_c^i of zero (0). In this formulation skilled labor is assumed to receive the residual returns over cost. Subscript c denotes skilled labor acitivities.

Z_d^i = Farm wage rate per hour for unskilled labor in producing farm output i. Subscript d denotes unskilled labor activities.

X_d^i = Total unskilled labor hours used for farm output i.

Z_e^j = Wage rate per hour of non-farm workers in producing non-farm output j. Subscript e denotes activities of non-farm workers.

X_e^j = Total skilled labor hours used for non-farm output j.

X_f^j = Total dollar value of non-farm output j which has an objective function value of zero (0). Subscript f denotes non-farm output activities.

IML = Total imported skilled labor hours which is discounted relative to local labor by transportation value M of 10 cents.

Y = Regional final demand.

WL_s = Regional skilled labor supply.

WL_u = Regional unskilled labor supply.

FOP = Farm operators in the skilled labor supply.

SIM = Skilled imported labor supply.

WLD = Regional agricultural land supply.

K_a & K_f = Coefficients of import purchase

LD_b = Coefficients of land use.

fL_s = Coefficients of skilled labor use in agriculture.

fL_u = Coefficients of unskilled labor use in agriculture.

NL = Coefficients of skilled labor use in other industry.

Similar to the general linear programming model that maximizes total output X, the short run area model (SRAM) is composed to two major parts: agricultural output X_b^i and non-agricultural output X_f^j. For agricultural output X_b^i, SRAM maximizes the total value of output minus variable cost (including hired labor cost) which represents the farmers' net return to operator and capital. Total cost (X_a^i) and labor cost activities (X_c^i and X_d^i) are included in the model and must occur simultaneously with returns from agricultural production. For non-agricultural output, X_f^j, the SRAM maximizes the non-farm wage return to labor activities (X_e^j) which also must occur simultaneously with every 1 dollars worth of non-agricultural production. Zero coefficients are assigned to the non-farm production activities so that instead of maximizing total output volume this model will maximize farmers' net cash return and non-farm workers' labor income subject to restraints of limited land and labor; subject to satisfying current contractual demand; and subject to short-run upper limits on total output imposed by current capital investment.

This model was developed to meet the practical needs of area development personnel. In several conferences designed to provide guidance for this study, industrial planners and managers in the Coosa Valley Area stated their principal problem as a need to understand labor force distribution and competition for labor supply within the area. Given this knowledge they felt they could best direct their efforts to obtaining funds for training workers to match jobs.

The justification for maximization of labor returns as an objective is that as labor moves among the industries and counties it tends to follow high wage rates. Furthermore, labor force movement or job transfers are assumed to take place more rapidly than capital investment. Some established firms in the area reported hiring more workers within one year than the number of jobs defined. Thus, the short-run of the model is a length of time in which labor supply can adjust to wages with level of technology and production capacity, or capital fixed. In the short-run, industry can expand output up to the limits of capacity according to restraints on land and labor and ability to compete for labor through the wage rate. The area is considered to be small relative to the national market in which it sells. Since its share of total output is so small, output capacity is considered to be the major exogenous restraint on output rather than market demand. Essentially, market demand is assumed to be perfectly elastic. If this proves not to be the case, product demand curves could be incorporated into the model.

The skilled labor force of farm operators and non-farm workers is assumed to move into either farm or non-farm jobs in a competitive and open economy. The skilled labor force of the model consist of (1) the estimated number of farm operators and (2) wage earners in the labor force who pay unemployment security taxes. Federal and State employees, however, are excluded. Farm labor other than operators is assumed to be unskilled labor and may not be transferred to the skilled labor force. It is possible for the model to transfer skilled labor into the unskilled category only if unemployment in the skilled labor market exists in the model. If unemployment of skilled labor is observed as a result of any particular analysis then a transfer activity must be added to explore the

impact on agriculture of hiring the unemployed at unskilled rates.

Thus, the objective function specifies for the agricultural sub-model that returns above variable costs accrue to the farm operator. Under these conditions each agricultural activity (X_b^i) represents a demand for labor. Demands for labor in commerce and industry are represented by a labor use activity (X_e^j) for each industry. Aggregate demand for labor may be thought of as the sum of all labor use activities in the model. The aggregate supply of labor is specified in the right-hand side values (WL_s, WL_u, FOP, SIM) of the linear programming constraints. Right-hand side values also specify final demands (Y) which are necessary to derive the demand for labor. Agricultural land is also restricted by right-hand side values (WID). In general, any relevant category of resource restriction could be added as an additional row of the model.

The role of the objective function is to direct labor into its highest and best opportunity as indicated by neoclassical theory. Neoclassical theory of wages is far from realistic yet it persists as a useful tool in examining labor markets.[1/] Criticisms of the model are thus the same as those which apply to theory. There is lack of knowledge concerning alternative job opportunities, there are real costs of moving to a new job, there are psychic costs of moving, there is heterogeneity of the labor supply, there are artificial barriers such as unions and discriminatory practices, and there is the threat of unemployment which may be higher for job changers. Nevertheless, this model, like theory, is structured to search for an equilibrium based on economic motivation. Furthermore, as data for the above shortcomings of the model becomes available, the model can be expanded to contain the additional detail.

The model departs from neoclassical theory in one major respect.

In theory, the wage return is independent of the return to capital. As the worker changes his job or location his capital is reinvested at the same rate of earning. In building a model disaggregated mostly with respect to agriculture, explicit recognition was taken of the fact that the farmer's return on selling out his investment is generally less than a beginning farmer's costs. Return to capital was thought to be very important to the farmer in the short-run and thus returns above variable cost was thought to be the relevant measure of current demand for farm operator labor.

Upper Bounds

Total output of non-agricultural activities were specified based on the assumption of fixed capacity. Capacity restraints were, therefore, estimated for each industry. Upper bounds were also estimated for agricultural activities. Since a general upper bounds procedure was used in programming, these restrictions do not formally appear in the model.

Data

Data for the model were taken mainly from the Census of Agriculture, employment and wages reported by the Georgia State Labor Department, budget studies of the Department of Agricultural Economics and data provided by the Coosa Valley Planning and Development Commission. Model coefficients were estimated by Liu.

RESULTS AND APPLICATION

The model was tested against available information in 1972 and then used to simulate production and resource use in the Coosa Valley economy.

The results obtained with the 1972 model represented a situation of

output and resource use which could be attained given the available information. Conditions in 1972 were used to specify many coefficents in the model and it should simulate that year very well. However, the maximization technique of the model will be expected to project results in an economy which is operating at maximum labor market efficiency. Thus, we should detect desirable adjustment possibilities. For example, the model indicates more production in high wage industries than may have occurred under existing conditions. It also shows those industries, including disaggregated agriculture, that would lose production if labor is attracted to it's highest and best use.

Agricultural Production and Farm Resources Use

The model's results in agricultural production were compared with the ratio projections from the Census of Agriculture, Table 3. As shown in Table 3, most of the model estimates on sales of each activity are lower than those projected from census to 1972, except for soybeans. Soybeans produced additional exports rather than merely satisfying the minimum final demand requirements and interindustrial demands. Three facts may explain these differences: (1) The competitive market condition for labor use will transfer labor from agricultural to non-agricultural activities for higher returns except for soybean production. The maximization technique of the model is expected to project results of this type unless the observed economy was operating at maximum labor allocative efficiency. (2) The right hand side values of skilled and unskilled labor available for agricultural production were effective restraints on the model. All labor available was used. To the extent that farm labor would not move to industry, based on conditions in 1972, farm output may have been underestimated. (3) The

fact that none of the non-model estimates are completely accurate, they are subject to error of observation. Also, aggregation errors undoubtedly occured during construction of the model.

Skilled labor used by agricultural activities is shown in Table 3. Total skilled labor hours used by agricultural production is 7,687,604 hours or 2,563 full time operator equivalent while the net on-farm operators derived from 1969 census was 3,146 full-time man equivalent. Thus, about 583 farm operators could feasibly transfer to non-agricultural activities in the model compared to the 1969 census. Unskilled labor was used up by agriculture within the model. When an increase in unskilled labor was simulated by increasing the right hand side value of unskilled labor available, less operator mobility was indicated. In other words, agriculture was more profitable than non-farm work if the unskilled labor supply was adequate. Conversely, one could argue that some farmers might increase the amount of unskilled labor available by paying higher wages, thereby, increasing the profitability of agriculture and keeping more skilled labor on farms. According to our recent surveys there does appear to be a small group of commercial farmers in Georgia who pay significantly higher wages than average for unskilled labor. Apparently, this group should become larger. Maximum agricultural production was further simulated by releasing the final demand requirements for agriculture. One other way of looking at this assumption is that it specifies that farmers would adjust in one year to profit maximizing crops with no regard to tradition or historical production mix. Under this full adjustment simulation, the agricultural production mix is simplified by producing the most profitable activities under the available resources, i.e., soybeans, commercial eggs and dairy. Even in this case, about 225 additional farm operators would work off-farm

compared to the 1969 census.

Agricultural land was not used up by the base model production; 743,411 acres out of 994,655 acres were being used, i.e., about 75 percent. Thus, the restriction of available skilled and unskilled labor limits the extensive use of agricultural land.

Non-Agricultural Activities and Labor Use

The base results indicated that Paper & Allied Products, Chemicals & Allied Products, Electrical Machinery & Equipment, Transportation Service and Communication & Utilities could produce exports in excess of current final demand under the competitive wage rate and resources restraints. The other non-agricultural activities would produce only the specified short-run levels of interindustrial demands and final demand. In the base result, local skilled labor and import labor available to the area would be used up by both agricultural and non-agricultural activities.

Model results were compared with labor department data on employment and sales projections based on output-employee projections, (Table 4). Non-agricultural sales projected from the model were higher than those projected with labor department data. This is consistent since the model projects less agricultural sales. This is the expected guns versus butter substitution effect that will occur in the aggregate when limited resources are allocated efficiently.

Import

Import value calculated in the model represents the total purchases of the Coosa Valley Area from outside of the area. In 1972 this would have been 227.33 million dollars for all the production and sales in the base model. Of course, any known shortage of imports by industry, such

as energy, water or manufactured goods could easily be added at this point, but no data were available for this study.

Summary and Conclusions

The capacity of agriculture as a pool of labor for future economic growth in the Coosa Valley appears to be very limited. An additional 500 workers that might move to industry would represent only .8 percent of the total labor use observed. What may be more important is that current wages in industry for skilled labor, farm wages of unskilled labor, and resultant supply of unskilled labor are such that farm production is likely to be depressed. A continuation of conditions like these in 1972 might feasibly lead to decreased production at a time when mational and world conditions might indicate a need for greater agricultural output.

While Coosa Valley is only a small part of our production potential it is representative of some problems of agriculture in a highly industrialized society. Improvements must be made in labor returns of both operators and hired workers, otherwise, owner-operator farms will continue to decline. Consequently, agricultural production capacity will be diminished.

The model also contained results applicable to non-agricultural industry. Improvements on the objective function arise from transferring labor to its highest value of marginal productivity (VMP). The model assumes mobile and homogenous skilled labor and on this basis develops demand for labor in each industry. While this provides some general implications, more detailed budget analysis of education costs to provide skilled labor could be made based on the study. The added return from VMP could be compared with budgeted educational costs implied in making a transfer. Where benefits are positive these investments in education

should be made as these are the jobs to be filled in industries that contribute to maximization of aggregate area returns to labor. A more general approach could include costs of labor transfer directly in the model.

Finally, the model serves as a filing system for economic data describing the Coosa Valley. It should be considered the starting point for a permanent aggregate model subject to continue improvement by area development personnel.

Table 1. Agriculture Activity List for Counties in the Coosa Valley APDC, Georgia, 1972.

Model Code	Name	Output Unit
RI - 101	Cotton	1,000 lbs.
- 102	Corn	100 bu.
- 103	Soybean	100 bu.
- 104	Wheat	100 bu.
- 105	Oats	100 bu.
- 106	Coastal Hay	10 tons
- 107	Beef	100 lbs.
- 108	Feeder Calf	100 lbs.
- 109	Sow Pig and Market Hogs	100 lbs.
- 110	Feeder Pigs	100 lbs.
- 111	Commercial Broilers	100 lbs.
- 112	Commercial Eggs	100 dozens
- 113	Dairy-Milk	100 lbs.
- 114	Apple	100 bu.
- 115	Tomato	100 lbs.
- 116	All Others	dollars

Table 2. Industrial Sectors in Counties of the Coosa Valley APDC, Georgia, 1972.

Model Code	Name[1/]
RI - 117	Mining
RI - 118	Contract Construction
RI - 119	Food and Kindred Products
RI - 120	Textile Mill Products
RI - 121	Apparel and Related Products
RI - 122	Lumber and Wood Products
RI - 123	Furniture and Fixtures
RI - 124	Paper and Allied Products
RI - 125	Printing and Publishing
RI - 126	Chemicals and Allied Products
RI - 127	Rubber and Misc. Plastics
RI - 128	Leather and Leather Products
RI - 129	Stone, Clay and Glass Products
RI - 130	Primary Metal Industries
RI - 131	Fabricated Metal Products
RI - 132	Machinery, Except Electrical
RI - 133	Electrical Machinery & Equipment
RI - 134	Transportation Equipment
RI - 135	Miscellaneous Manufacturing
RI - 136	Transportation Service
RI - 137	Communication & Utilities
RI - 138	Wholesale and Retail Trade
RI - 139	Finance, Insurance, Real Estate
RI - 140	Services
RI - 141	Federal Government Enterprises
RI - 142	State & Local Government Enterprises
RI - 143	Unallocated Industries

[1/] Output Unit = Dollars

Table 3. Model Results for Agricultural Sales and Labor Hour Used Compared with Projected Sales from Census, Coosa Valley of Georgia, 1972.

	Projected Sales of Coosa Valley from Census, 1972	Model Results	
		Sales of Coosa Valley, 1972	Skilled Labor Used
	----------dollars----------		---hours---
Cotton	6,083,653	5,696,825	291,368
Corn	1,167,091	1,092,531	83,462
Soybean	1,701,175	2,314,502	94,005
Wheat	74,416	69,248	4,001
Oats	57,530	53,871	3,450
Hay	2,682,146	2,511,207	50,224
Beef	11,920,989	11,188,048	1,087,636
Feeder Calf	111,186	103,795	2,463
Sows & Market Hogs	2,016,461	2,006,997	267,089
Feeder Pigs	553,966	518,520	1,763,683
Commercial Broilers	5,856,610	5,483,971	370,901
Eggs	1,001,113	937,490	123,680
Dairy Milk	6,844,312	6,408,864	131,154
Apple	2,256	2,256	34
Tomato	56,319	52,560	618
Others	20,255,825	18,965,921	3,413,866
TOTAL	60,385,049	57,406,606	7,687,604

Table 4. Model Results on Non-Agricultural Sales and Skilled Labor Use, Compared with Labor Department Data, Coosa Valley, 1972.

Industry	1972 Sales: Projected with Labor Department Data	1972 Sales: Model Results	Skilled Labor Used: Employment from Labor Department Data	Skilled Labor Used: Model Results
	-------thousand dollars------		--------man equivalents-------	
Mining	15,242.2	15,490.4	449.8	457.0
Contract Construction	82,031.3	82,471.7	2,629.1	2,643.2
Food and Kindred Products	83,267.0	88,174.9	1,590.2	1,684.1
Textile Mill Products	1,061,280.0	1,061,547.4	28,554.6	28,555.6
Apparel and Related Products	111,399.0	111,473.3	7,125.3	7,128.7
Lumber and Wood Products	9,231.7	9,390.7	391.1	397.7
Furniture and Fixtures	19,608.4	19,613.6	861.2	861.0
Paper and Allied Products	75,062.7	83,938.4	1,427.2	1,594.8
Printing and Publishing	8,663.9	8,708.7	334.2	336.2
Chemicals and Allied Products	55,109.2	68,940.6	1,084.1	1,354.7
Rubber and Misc. Plastics	53,904.6	54,170.8	1,653.7	1,663.0
Leather and Leather Products	994.4	996.8	58.3	58.4
Stone, Clay and Glass Products	16,067.0	16,224.3	540.8	546.0
Primary Metal Industries	16,416.9	16,470.0	357.4	358.2
Fabricated Metal Products	26,433.1	26,937.4	830.8	847.2
Machinery, Except Electrical	22,454.8	22,601.8	669.0	673.5
Electrical Machinery & Equipment	59,189.2	60,345.2	1,719.4	1,753.0
Transportation Equipment	1,450.8	1,451.0	27.7	27.6
Miscellaneous Manufacturing	2,218.6	2,229.6	66.1	66.4
Transportation Service	20,052.8	21,225.0	1,114.8	1,180.1
Communication & Utilities	55,401.7	56,214.9	1,425.1	1,444.7
Wholesale and Retail Trade	162,634.0	164,366.6	10,835.3	10,946.8
Finance, Insurance, Real Estate	111,367.0	112,343.2	1,862.9	1,881.75
Service	103,975.0	104,625.6	4,135.4	4,158.9
Federal Government Enterprises	16,107.0	16,176.4	N/A	N/A
State and Local Government Enterprises	14,918.0	15,013.3	N/A	N/A
Unallocated Industries	22,277.0	22,848.5	N/A	N/A

N/A - Not Available.

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FOOTNOTES

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1/ A useful review of these concepts is provided by Lianos [5].